

Master Timing System Measurements

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This article describes the test results obtained for the Master Timing System (MTS) manufactured for Goddard Space Flight Center and deployed at the Tracking and Data Relay Satellite Systems Station in White Sands, N.M.

I. Introduction

The tests described in this article were performed on the Master Timing System (MTS) presently in use at the Tracking and Data Relay Satellite Systems (TDRSS) Ground Station at White Sands, N.M. This system was manufactured for Goddard Space Flight Center (GSFC) by TRAK Systems, and is similar in all respects to the master clocks to be utilized in the MK IVA Frequency and Timing Subsystem. Three of these clocks are being purchased by GSFC to be transferred to JPL upon consolidation of the DSN and STDN. The fourth clock is being procured by JPL for future implementation into the DSN. Operating parameters and performance criteria were necessary to ensure subsystem performance and institute design changes for the new clocks.

This report is a composite of two test runs performed on the MTS. The primary tests were conducted on 9 December 1980 through 11 December 1980. These tests were inconclusive due to test equipment malfunctions. Follow-up tests were conducted on 3 February 1981 through 5 February 1981, with all results being verified.

II. Test Descriptions

During the two test runs, the following tests were performed and the results of these tests explained.

- (1) *Port-to-port isolation.* The output ports were tested for isolation by observing the output while subjecting the adjacent ports to varying loads, i.e., open load to short circuit. Both amplitude and phase of the test ports were monitored. The first trial of this test produced a complete failure of all outputs; however, subsequent exhaustive tests failed to produce any perturbations. No significant change in amplitude or phase could be measured at any output port.
- (2) *Sine wave outputs.* All sine wave outputs were measured for isolation, amplitude and distortion. Distortion was not measured by a qualitative means; however, no distortion could be detected on a 400-MHz storage oscilloscope. All outputs were within specified limits for isolation ($<0.1\%$ change in amplitude with any output open or shorted) and amplitude (adjustable from 2 to 5 V(p-p)), and the distortion could be stated to be below five percent.
- (3) *Serial time codes.* The serial time codes were clean and within specifications. The amplitude was measured to be 3 V(p-p), and the mark-space ratio was adjustable from 2:1 to 4:1.
- (4) *Timing pulses.* Pulse amplitude, wave shape, rise time, and jitter were measured, and the results of each category are presented below. All measurements were made with the output terminated into 50 ohms.

- (a) *Amplitude*. The positive or "on" portion of each pulse was measured to be $+3.5 \pm 0.2$ V and the negative or "off" portion was $+0.2 \pm 0.1$ V.
- (b) *Wave shape*. Each set of pulses displayed a different shape, which can best be described by drawings of those waveforms. These drawings are presented in Fig. 1.
- (c) *Rise time*. Rise time was measured utilizing a 400-MHz storage oscilloscope. All pulses displayed a rise time of less than 15 nsec between the 10 and 90% points.
- (d) *Jitter*. Pulse jitter was measured by redundant systems utilizing an HP 5370 time interval counter and a standard clock with an HP 9835 computer doing the controlling and data reduction for each of the two systems. The in-house frequency standard was utilized for external synchronization of the counters and clocks to insure maximum coherence of each test channel. The standard clocks were measured to have pulse jitter of less than 50 picosec. The pulse output of the MTS was compared against these standard clocks for this test. The data were taken at 100-sample increments and an accumulation of the drift, rms (1σ deviation), positive and negative peak deviation was compiled by the computers. Plots of the reduced data are presented for each of the pulse rates in Figs. 2 through 5. The maximum accumulated values for each pulse rate are given in fractional seconds below:
- (e) *Duty cycle*. The pulses displayed at 80% on-time and a 25% off-time duty cycle as specified by Goddard. This can be modified to provide a 10- μ sec pulse width to meet JPL requirements.
- (f) *Slew rates*. All pulse slew rates were surprisingly accurate; even the 50-nsec/sec rate was exactly 50 nsec per step.
- (g) *Pulse coincidence*. The timing coincidence between different output ports was less than 5 nsec between the slowest and fastest pulse of a set (e.g., all 1 pps ports).
- (h) *Zero crossing coincidence*. The worst case offset of the zero crossings of the 5-MHz reference signal and the leading or rising edge of the 1 pps was less than 50 nsec.

III. Conclusion

The test results indicate that the system performs within the specifications established by Goddard Space Flight Center. The overall system appears to be well designed and built to a good commercial grade. The Triple Redundant Time Code Generators, whose outputs are majority voted, performed adequately as far as could be determined on an operational system. The automatic fault isolation circuitry could not be tested, due to the system being in an operational situation.

This timing system has been in operation at the TDRSS station for more than one year with no reported failures.

The failure noted in paragraph II (1) apparently was caused by a disturbed reference cable or loose connection external to the clock.

The inconclusive results obtained during the first test run were caused by a perturbation in the data, for which the cause could not be determined. The first test run did not utilize redundant test systems.

Pulse rate, pps	RMS jitter	Positive peak jitter	Negative peak jitter
1	4.73×10^{-10}	1.25×10^{-9}	-1.44×10^{-9}
10	4.75×10^{-9}	1.47×10^{-9}	-9.34×10^{-9}
100	8.03×10^{-10}	2.24×10^{-9}	-3.05×10^{-9}
1000	4.41×10^{-9}	1.08×10^{-8}	-9.24×10^{-9}

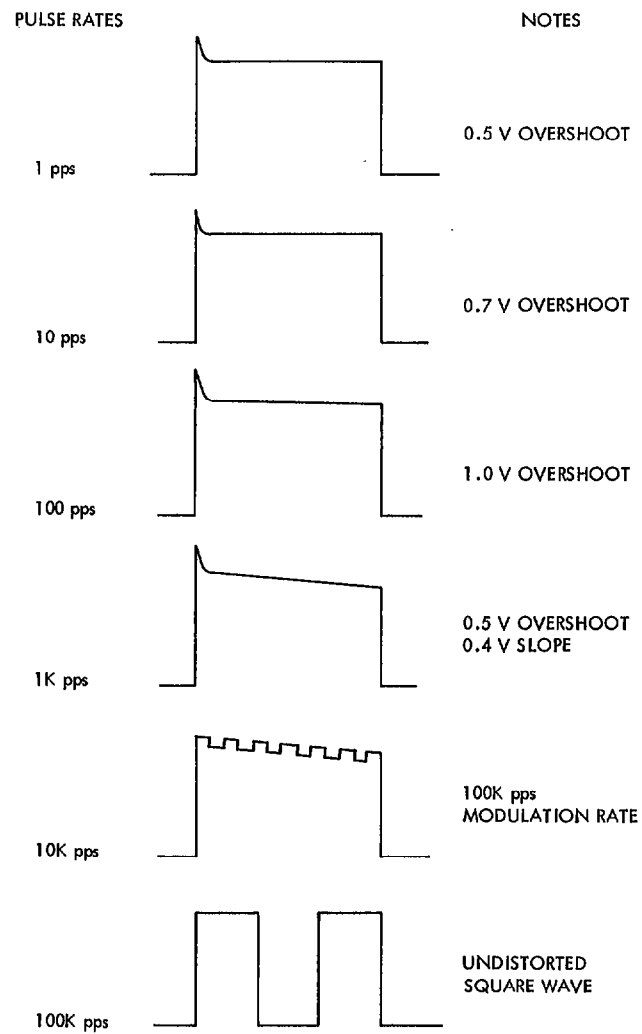


Fig. 1. Timing pulse waveforms

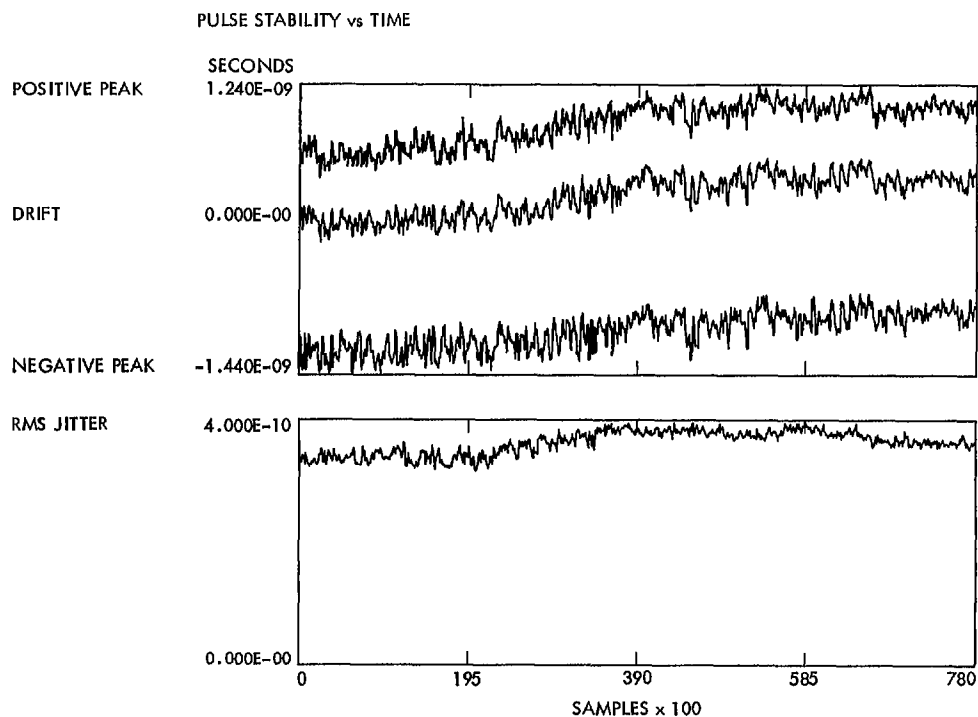


Fig. 2. 1-pps timing pulse

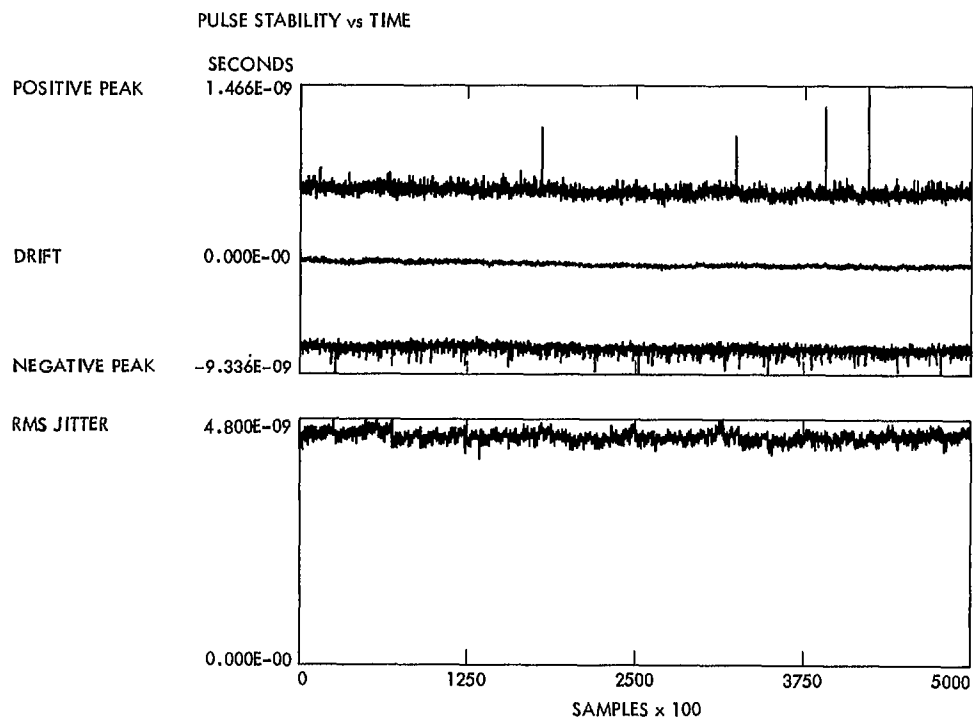


Fig. 3. 10-pps timing pulse

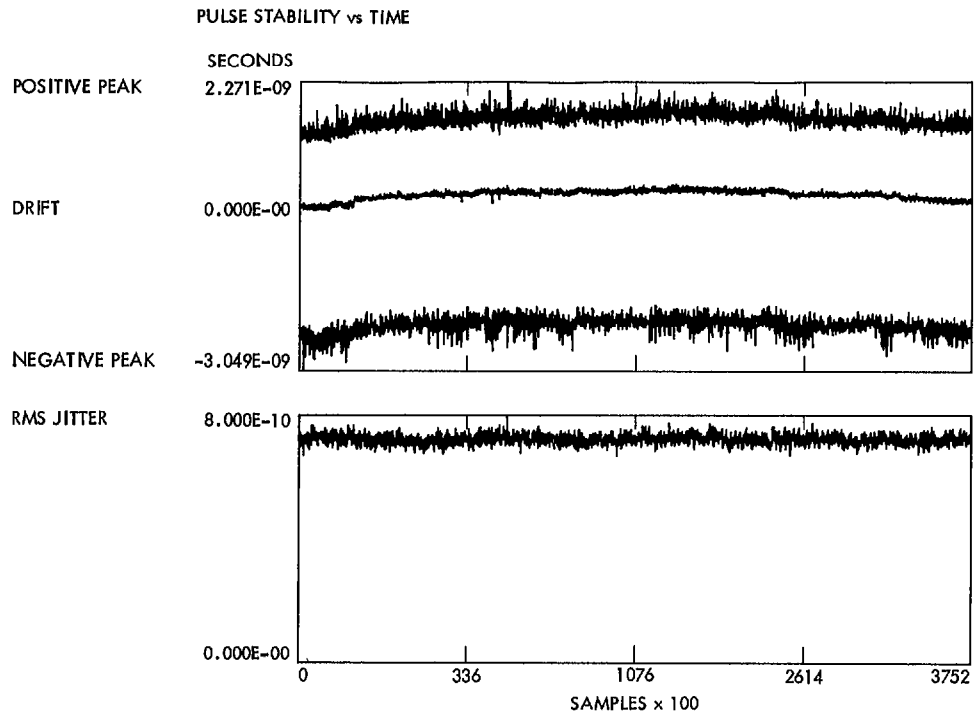


Fig. 4. 100-pps timing pulse

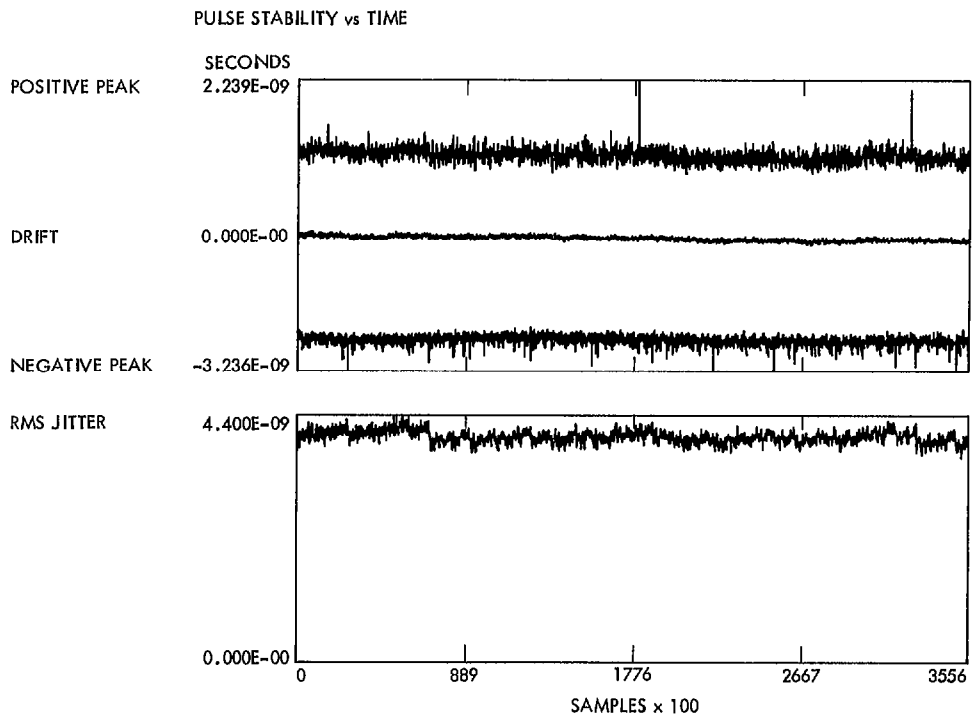


Fig. 5. 1000-pps timing pulse